Chapter 6 - San Luis Reservoir

Potential Contaminant Source or Watershed Activity	Report Section	Water Quality Parameters								
		TDS/ Salts	Organic Carbon	Bromide	Pesticides	Nutrients	Pathogens	Trace Elements	Turbidity	T&O
Recreation	6.3.1		○				◒		◒	
Wastewater Treatment/Facilities	6.3.2					○	○			
Animal Populations	6.3.3		○			◒	◒		◒	
Algal Blooms	6.3.4								○	◒
Agricultural Activities	6.3.5	○			○	○				
Traffic Accidents/Spills	6.3.6							○	○	
Geologic Hazards	6.3.7		○						◒	
Fires	6.3.8		○						◒	

<u>Rating symbols:</u>

● PCS is a highly significant threat to drinking water quality

◒ PCS is a medium threat to drinking water quality

⊙ PCS is a potential threat, but available information is inadequate to rate the threat

○ PCS is a minor threat to drinking water quality

Blank cells indicate PCS not a source of contaminant

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6
San Luis Reservoir

6.1 WATERSHED DESCRIPTION

The San Luis Reservoir is 12 miles west of the city of Los Banos on San Luis Creek between the eastern foothills of the Diablo Range and the west foothills of the San Joaquin Valley in Merced County. This major offstream reservoir of the joint-use San Luis Complex stores excess winter and spring flows from the Sacramento-San Joaquin Delta and supplies water to service areas for both the State Water Project (SWP) and the US Bureau of Reclamation's Central Valley Project (CVP). The San Luis Reservoir and its watershed encompass 85 square miles (Figure 6-1). Water is used for agricultural, industrial, municipal, and recreational uses as well as for fish and wildlife enhancement.

6.1.1 LAND USE

The California Department of Water Resources (DWR) and US Bureau of Reclamation (USBR) own most of the San Luis Reservoir watershed. A small fraction of the watershed mostly on the south side of the reservoir outside the recreational boundaries is private agricultural land (Montoya pers. comm.). California State Parks manages recreational use of the land adjacent to the shoreline. The US Bureau of Land Management (BLM) manages the remainder of the watershed.

The San Luis watershed is mostly undeveloped except for recreational improvements. The BLM allows some seasonal livestock grazing on its land near the reservoir, but no farming or land development has been permitted. The semi-arid climate in combination with generally poor to moderate grass cover and steep slopes limit livestock grazing activities around the reservoir watershed. Intermittently, cattle and sheep graze on non-native grassland in the watershed.

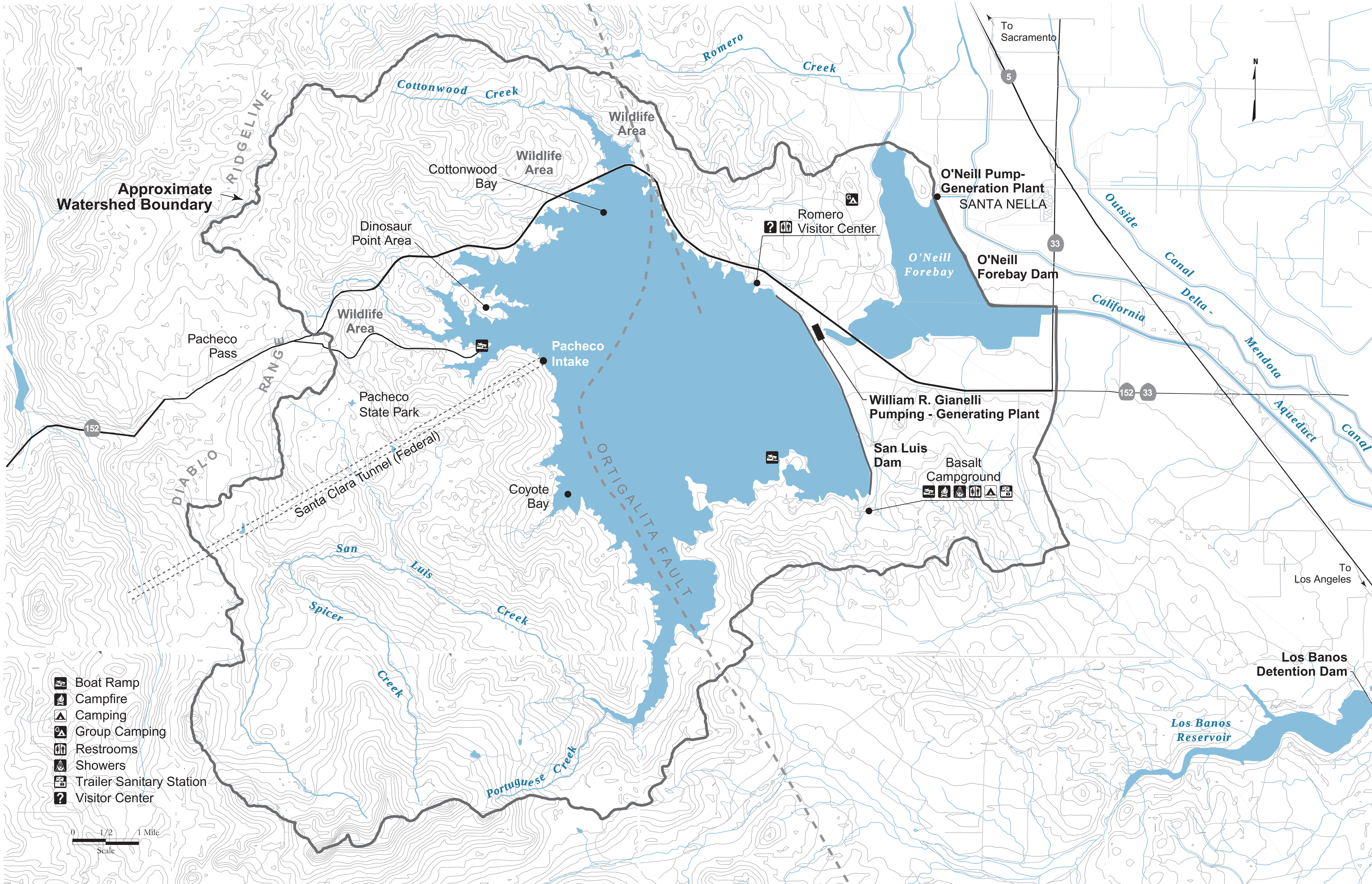
California State Parks operates the San Luis Reservoir State Recreation Area (SRA). Extensive recreational development and 3 wildlife areas are around the reservoir.

6.1.2 GEOLOGY

The San Luis Reservoir watershed is on the eastern portion of the Diablo Range, along the western edge of the San Joaquin Valley near Santa Nella (Figure 6-1). Surface geology is predominated by the Tulare Formation developed during the Plio-Pliestocene Age, which generally consists of San Joaquin Valley floor sediments exposed along the eastern edge of the Coast Range. The Tulare Formation was uplifted, broadly folded, locally faulted, and dissected by stream incision in late-Quaternary time (DWR 2000a). Late Pleistocene to recent fluvial deposits rest on the Tulare Formation, often as terrace deposits along modern stream channels. The underlying Great Valley Sequence bedrock consists mainly of conglomerate with interbedded shale and sandstone, and minor sandstone of the Panoche Formation (DWR 2000a).

The watershed has several rock types. The northwestern portion of the reservoir mainly is composed of a melange of sheared fragmented Franciscan Complex rocks (California 1977). The area near B.F. Sisk San Luis Dam and the O'Neill Forebay area east of the reservoir are primarily nonmarine sedimentary rock, and include loosely consolidated sandstone, shales, and gravels. A small portion of the northern shore of the O'Neill Forebay contains terrace deposits from various sources from the Great Valley Syncline. These deposits are both consolidated and semiconsolidated and may be categorized as mostly nonmarine sedimentary rock, possibly including some marine deposits. The surface geology of the watershed for the remainder of the reservoir complex is very similar to that of Lake Del Valle, with the exception of a small area of igneous rock along the Ortigalita fault north of the lake. The igneous rock is mostly serpentinite but may include peridotite, gabbro, and diabase.

Figure 6-1 San Luis Reservoir



6.1.3 SOILS

Soils in the reservoir watershed are mostly coarse-textured mineral soils with low organic carbon content and low water-holding capacity. Some relatively finer textured soils develop on lower elevations near O'Neill Forebay. Dominant soils in the watershed include the Millsholm series, Oneil series, Fifield series, and the Honker series (USDA 1990). Other important soils include the Akad, Appollo, Conosta, Franciscan, Gonzaga, Quinto, Damluis, Bapos, and the Los Banos series (USDA 1990). These soils often occur in combinations, associations, or complexes with one another or with rocks, particularly in steep slopes of the watershed. On low terraces of the watershed (slopes from 0% to 15%), soils are deep, well-drained clay loams. On the foothills (15% to 30% slopes), soils are moderately deep silt and clay loams. On sloping to steep slopes (30% to 75% slopes), soils are mostly well drained sandy, gravelly, cobbly, or bouldery loams. Most soils in the watershed are susceptible to water and wind erosion, and soil loss may occur during heavy surface runoff.

6.1.4 VEGETATION

Vegetation of the mostly uncultivated San Luis watershed is composed of Valley Grasslands with Valley Oak Woodlands near drainage areas (Schoenherr 1992). Primary plant species include filaree (*Erodium botrys*), soft chess (*Bromus hordeaceus*), foxtail fescue (*Vulpia myuros (L.) C. Gmelin var. hirsuta (Hackel) Asch. & Graebner (Poaceae)*), blue oak (*Quercus douglasii*), interior live oaks (*Quercus wislizenii*), valley oak (*Quercus lobata*), ripgut brome, Californian buckwheat (*Eriogonum fasciculatum var. polifolium*), and red brome (*Bromus madritensis ssp. Rubens*). Tree canopies vary from 15% to 50% (USDA 1990). Oak woodlands dominate the foothills with blue oaks, interior live oaks (*Quercus wislizenii*), and valley oak (Schoenherr 1992). In areas of the watershed that have been grazed, native species mostly have been eliminated. Needle grass (*Stipa/Nasella sp.*) and sparegrass (*Stipa/Nasella sp.*) are the dominant native grasses (Schoenherr 1992).

6.1.5 HYDROLOGY

The surface water hydrology is typical of the semi-arid watersheds in the southwest part of the San Joaquin Basin. There are 6 major creeks in the watershed. Five creeks—Hidden Creek, Portuguese Creek, Salt Creek, San Luis Creek, and Spicer Creek—are in the southwest sector; Cottonwood Creek is in the northwest (Figure 6-1). The watershed area is 85 square miles with the reservoir comprising nearly 25% of the total. The daily maximum temperature in this part of the San Joaquin Valley ranges from 80 to 100 degrees Fahrenheit in summer and from 45 to 65 degrees Fahrenheit in winter. Records from the nearby Los Banos Dam precipitation station (operated by DWR) show an average annual rainfall of 9.7 inches between 1961 and 2000. A maximum annual rainfall of 24.1 inches occurred in 1998, and a minimum of 3.5 inches occurred in 1989 at the same station (DWR 2001).

During the 1950 to 1962 water years, the US Geological Survey maintained a streamflow monitoring station on San Luis Creek at the current Sisk Dam site. The average annual streamflow for that period was 4,260 acre-feet (af) (USGS 1963). According to the San Joaquin Valley Water Year Hydrologic Classification Index, a comparative index maintained by the Division of Flood Management of DWR, the index average for the period from 1950 to 1962 was about 90% of normal (DWR 2001a). Based on this index, the average annual streamflow for the San Luis Creek station would be about 4,700 af. Table 6-1 shows the estimated total annual natural inflow for 1996 to 1999. The data indicate that during this period the natural inflow from the watershed was insignificant relative to the reservoir's total capacity.

Table 6-1 Estimated Annual Natural Inflow to the San Luis Reservoir (acre-feet)

1996	1997	1998	1999
5,700	7,600	8,300	4,700

6.2 WATER SUPPLY SYSTEM

The B.F. Sisk San Luis Dam forms the San Luis Reservoir. The dam is 18,600 feet long and 305 feet high. Water enters and exits through a common inlet/outlet tower. The USBR also pumps water out of San Luis Reservoir in a westerly direction to San Felipe Division Water contractors through the Pacheco Pumping Plant and the Santa Clara Tunnel (Figure 6-1).

The reservoir was completed in 1967 and first filled in 1969. It has a capacity of 2,027,840 af, a surface area of about 12,700 acres, and a shoreline of about 65 miles (DWR 1997). Maximum water depth of the reservoir is 295 feet; average water depth, 160 feet. About 67,000 af of water is lost annually to evaporation, considering the gain by annual rainfall. Most of the reservoir's water is pumped from the California Aqueduct and the Delta-Mendota Canal (DMC) via the O'Neill Forebay through the Gianelli Pumping-Generating Plant during winter and spring. The San Luis Reservoir water is delivered to San Joaquin Valley, Santa Clara Valley, and Southern

California when water supply in the California Aqueduct and the DMC is insufficient.

The section of SWP near San Luis Reservoir is operated and maintained by DWR's San Luis Field Division. Major facilities that make up this part of the system include the Gianelli Pumping-Generating Plant and O'Neill Forebay (Figure 6-1). Water diverted from the Delta by the Banks Pumping Plant enters the northern end of O'Neill Forebay. The water either flows through the forebay into the California Aqueduct on the southern side of the forebay or is lifted by the Gianelli Pumping-Generating Plant into San Luis Reservoir. The forebay also receives water from the DMC via the USBR's O'Neill Pump Generation Plant. The Santa Clara Valley Water District (SCVWD), a CVP contractor, has been receiving water from San Luis Reservoir through the Pacheco Intake (Figure 6-1) since 1965. The total annual maximum entitlement for SCVWD is 152,000 af, which is pumped through the Pacheco Pumping Plant on the western side of the reservoir near the Dinosaur Point area (Matthews pers. comm. 2001)The Gianelli Pumping-Generating Plant has 8 pumps with a total capacity of 11,000 cfs. Power is generated by reversing the water flow (17,600 cfs) from San Luis Reservoir to O'Neill Forebay.

6.3 POTENTIAL CONTAMINANT SOURCES

6.3.1 RECREATION

The San Luis Reservoir SRA is one of the most popular recreational facilities in the SWP. Activities in San Luis Reservoir include boating, camping and picnicking, fishing, swimming and water skiing, seasonal hunting, and sightseeing. Among the major potential contaminant sources (PCSs), recreation presents the greatest potential threat to water quality in the reservoir.

6.3.1.1 Body Contact Activities

Potential contamination of water in the reservoir through body contact recreational activities appears to be limited. Swimming, waterskiing, and windsurfing in the San Luis Reservoir are not restricted, but the area around San Luis Reservoir is often very windy. Gusty winds come up suddenly, and strong winds often cause boats to capsize. Occasionally, boaters, surfers, and swimmers drown. Use of the reservoir for swimming is light. Most swimming activities occur at the San Luis Creek area on the west side of O'Neill Forebay where a swimming area is roped off (Hardcastle pers. comm.).

6.3.1.2 Nonbody Contact Activities

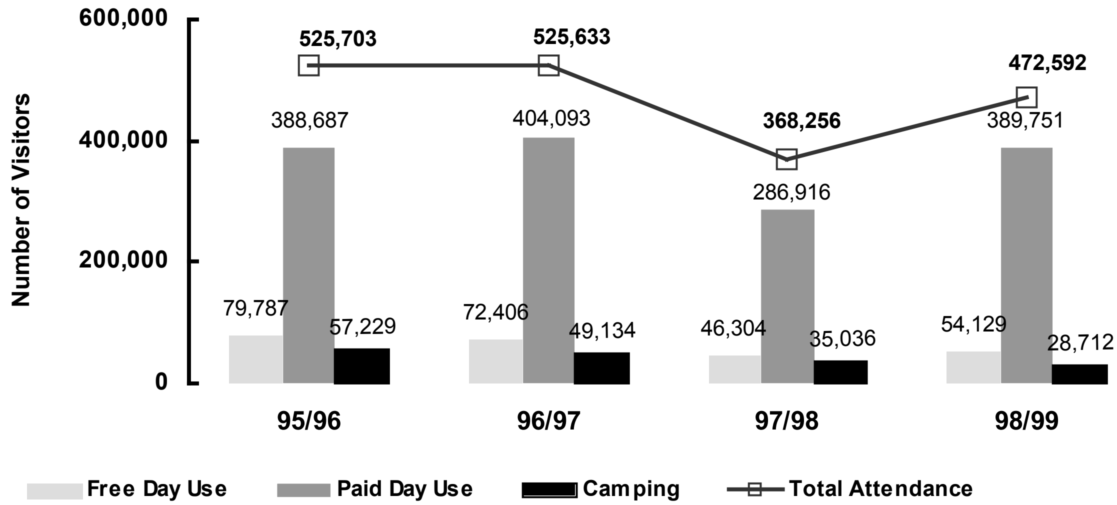
Many people visit the reservoir. Two major recreational areas, the Dinosaur Point Area on the west and the Basalt Area to the south, are close to the reservoir. The Romero Overlook Visitors Center on the east rim of the reservoir is 1 of the 3 visitor centers of the SWP.

Figures 6-2 and 6-3 summarize recreational use statistics in the San Luis Reservoir SRA (San Luis Reservoir, O'Neill Forebay, and Los Banos Reservoir) for the past 5 years. An average 473,000 persons visited the San Luis Reservoir SRA annually from 1995 to 1999 (Figure 6-2). The majority were paid day-users, and more than 10% of the visitors were campers (Figure 6-2). These numbers reflect visitors to all 3 reservoirs in the SRA. A DWR study suggests that approximately 42% of the SRA visitors went to San Luis Reservoir (Thrapp 1989). Therefore, an average of about 200,000 persons visited the San Luis Reservoir annually from 1995 to 1999.

Recreational area attendance is expected to rise because California State Parks lowered all use fees in the San Luis Reservoir SRA in 2000. During the 1999/2000 fiscal year, visitors to the Romero Overlook Visitors Center alone reached 207,380 (Biez pers. comm.).

The large number of visitors requires waste collection and disposal facilities, which include showers, toilets, wastewater treatment, septic systems, fish-cleaning amenities, and garbage collection sites. The Basalt Area is equipped with domestic water and a community wastewater collection, pumping, and disposal system. See Section 6.3.2, Wastewater Treatment/Facilities.

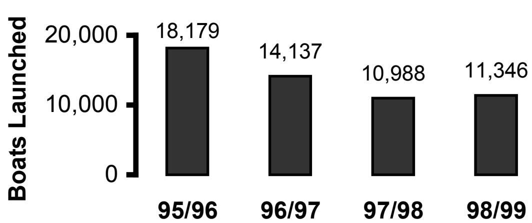
Figure 6-2 Visitors to the San Luis Reservoir Watershed, 1996 to 1999



Source: California State Parks Database, provided by Barry Montoya, DWR O&M, Feb 2001

There are no floating toilets on the reservoir. A portion of the shoreline is fenced and relatively clean. There are 2 major boat launch ramps in the San Luis Reservoir, 1 at the Basalt Area and the other at the Dinosaur Point Area (Figure 6-1). A variety of boats, including power and sail boats, rubber rafts, sailboards, canoes, and kayaks, are allowed to operate on the reservoir. An average of 13,700 boats was launched each year in the San Luis Reservoir SRA from 1995 to 1999 (Figure 6-3). The number of boats launched only in the San Luis Reservoir was not available.

Figure 6-3 Boating in the San Luis Reservoir



Source: California State Parks Database, provided by Barry Montoya, DWR O&M, Feb 2001

Boating activities in the reservoir directly contribute a variety of potential contaminants to the reservoir. These contaminants include diesel fuels, gasoline and their breakdown hydrocarbons, and gasoline additives such as MTBE. Turbidity and pathogens may also increase because of littering and wave actions. Wave actions from boating activities can cause erosion and landslides. However, the largest wave actions are caused by wind fetch across the reservoir. High winds can occur suddenly and pose a threat to boaters. In March 1997, 2 major landslides occurred because of boat wave-wash (DWR 2000b).

Runoff from campgrounds, roads, parking lots, and other recreational facilities in the SRA are potential sources of turbidity and pathogens in the reservoir. Bodies of humans and animals occasionally were found in the reservoir. Three drowning victims were discovered between 1996 and 2000 (DWR 2000c). Detailed records of dead animals are not available, but they were likely to be present in the reservoir because hunting of migratory waterfowl, pheasants, quail, rabbits, deer, and feral pigs is allowed in the reservoir area.

6.3.2 WASTEWATER TREATMENT/FACILITIES

Wastewater facilities include toilets, a recreational vehicle dumping and disposal system, and pumping stations. Treatment is provided by 2 oxidation/evaporation ponds at the northeast slope of the watershed. The ponds are constructed at deep slopes and are quite distant from the reservoir. Although seepage and overflow to the reservoir is unlikely, the potential for contamination to water in the reservoir is unknown. The Dinosaur Point Area and the remaining recreational development around the reservoir use portable chemical toilets, which have been well maintained. The Romero Overlook Visitors Center has wastewater service with disposal in nearby evaporation/percolation ponds.

6.3.3 ANIMAL POPULATIONS

6.3.3.1 Livestock Grazing

Grazing is allowed on certain public lands of the watershed between October and April, which coincides with the rainy season. For example, at the Pacheco State Park (Figure 6-1), about 2,000 acres of the 7,000 acres are contracted for cattle grazing, and up to 640 cattle are allowed from October to March of each year (Hardcastle pers. comm. 2001). The total number of animals and grazing days during the survey period is not known. Most of the area outside the recreational boundaries on the south side of the reservoir is privately owned and fenced for cattle grazing (Montoya pers. comm. 2001). Grazing on private lands is generally more intense than on public lands in the watershed. Grazing activities may cause runoff and erosion and is a potential source of nutrients, turbidity, and pathogens. DWR staff report that cattle have been seen in the water near Cottonwood Bay.

6.3.3.2 Wild Animal Populations

Figure 6-1 shows the approximate location of 3 wildlife areas near the reservoir. California State Parks manages the areas. Major species in the general watershed include cattle, feral pigs, elk, black bear, and black-tail deer (Gerstenberg pers. comm. 2001). Wildlife may be a PCS, but the impact is unknown. Most wildlife is on nongrazed land designated wildlife refuges, parks, or other recreational area. These nongrazed areas are usually covered with grass that may be 3 feet tall. The filtering action of such grass prevents animal wastes from entering the reservoir by surface runoff (Gerstenberg pers. comm. 2001). A tule elk herd resides nearby and has free run of the reservoir area (Montoya pers. comm.). Droppings from large populations of migrating waterfowl such as ducks and coots may be a water quality concern during winter months. The number of waterfowl landing in the reservoir depends on the growth of Swamp Timothy (*Heleochloa schoenoides*), a warm-season grass grown on moist soil and the most favored food of waterfowl in the grasslands. Along the reservoir banks and in dried areas, this grass germinates between February and September with optimal germination and growth occurring from mid-March to early May. When water in the reservoir recedes during this period, Swamp Timothy flourishes and attracts large populations of waterfowl to feed in the reservoir. As many 1 million birds landed in the reservoir during the last decade, and an average of 20,000 to 150,000 birds fed in the reservoir each year in recent years (Gerstenberg pers. comm. 2001).

6.3.4 ALGAL BLOOMS

Algal blooms are likely if other enrichment conditions are met. Nutrients in the reservoir were high during 1996 to 1999 and are discussed in Section 6.4.1.7, Nutrients. Taste and odor in the reservoir is a more serious water quality concern during drought years. In the fall, especially during drought years, a greater demand by SWP contractors creates a much lower water level in the reservoir. Because of the improved light penetration and greater likelihood of a thermocline in the reservoir, algal blooms mainly of blue-green *Aphanizomenon flos-aquae* are more likely to occur. During fall months, winds blow accumulated blue-green algae toward the intake, and taste and odor can be a concern.

The SCVWD is the only SWP contractor that withdraws water directly from the reservoir through the Pacheco Intake (see Figure 6-1). This intake is about 150 feet deep during normal reservoir operating conditions. Historical data suggest that algal blooms caused taste and odor problems for SCVWD during the drought years from 1992 to1993 (SCVWD 2001). During the survey period, however, SCVWD did not report any serious algal blooms, and taste and odor was not a serious water quality concern from 1996 to 1999, according to the flavor profile analysis records of SCVWD (SCVWD 2001). There were no drought years during this period, and precipitation records show that rainfall was heavy in 1995 and 1996 and reached a record high of 24.1 inches in the reservoir watershed during 1998. Because of less demand for water during the survey period, reservoir levels were relatively high. Strong winds mix surface water with water at greater depths, making it less likely that a thermocline will establish in the reservoir. Wind disturbances and the lack of a thermocline limited growth of blue-green algae (Janik pers. comm. 2001).

6.3.5 AGRICULTURAL ACTIVITIES

6.3.5.1 Pesticides

The herbicide Roundup is used around the reservoir for weed control. Roundup contains the active ingredient glyphosate, which is not mobile in soils. Use of Roundup in the watershed is not likely to affect water quality in the reservoir.

6.3.5.2 Agricultural Drainage

The major watershed drainage to the reservoir is from Cottonwood and San Luis creeks. Wheat and barley farms and some orchards are scattered in the reservoir watershed, but they are not close to the reservoir (Gerstenberg pers. comm. 2001). Because many farmers practice conservation measure, drainage is likely to be minimal (Gerstenberg pers. comm. 2001). Although agricultural drainage to the reservoir has not been estimated, it is generally believed that the limited number of barley and wheat farms in the watershed are away from the reservoir; therefore, runoff and drainage are considered a minor threat to water quality in the reservoir.

As discussed before, there is animal grazing on some private lands.

6.3.6 TRAFFIC ACCIDENTS/SPILLS

The reservoir is flanked by Highway 152 on the east and north sides. One section of highway crosses above an arm of the reservoir. Runoff from approximately 10 miles of this highway drains to the reservoir. Oil, grease, and other hydrocarbons from the road may enter the reservoir through runoff or wind. Highway 152 is a major transportation corridor in the area and a major route for trucks hauling hazardous wastes from coastal industries to the Kettleman Hills hazardous waste disposal facility in Kings County. Spills could result from trucking accidents. No documented spills or accidents occurred in the watershed from 1996 to 2000 (Montoya pers. comm. 2001).

6.3.7 GEOLOGIC HAZARDS

San Luis Reservoir is in a seismically active area and is close to 3 geologic faults. The Ortigalita fault passes under the reservoir, and the Calaveras and the San Andreas faults are 23 and 28 miles away, respectively. These faults and their segments can cause earthquakes at or near the reservoir.

From May 1984 to December 1999, 3 earthquakes with magnitudes of 3 to 4 occurred within 10 miles of the reservoir. One was in the reservoir itself, and another in the O'Neill Forebay. Within 46 miles of the reservoir, 86 earthquakes with magnitudes of 4 to 5 occurred. Within 82 miles of the reservoir, 12 earthquakes ranging from 5 to 6 magnitude occurred. Within 154 miles, 1 earthquake had a magnitude of between 7 and 8 in Santa Cruz County (DWR 2000b).

The wave actions of seismic and boating activities often cause landslides and erosion in the reservoir rims and embankments. For example, 2 major slide areas were discovered in March 1997. One was a boat wave-wash area at the base of the road embankment next to the entrance road to the Romero Overlook Visitors Center. This wave-wash area was 100 feet long and 8 feet high (DWR 2000b). The 2nd slide area, the largest identified during the 1997 inspection, was on the north shore of the reservoir parallel to Highway 152 in an excavation waste pile. The estimated volume of this slide was between 5,000 and 6,000 cubic yards (DWR 2000b).

The reservoir is also surrounded by hills and mountainous areas on both the south and west sides. The topography of the watershed, which is composed of numerous downstream slopes, is prone to landslides and erosion. Neither the frequency of such slides and erosion nor the potential for increases in turbidity or other water quality parameters of concern in the reservoir has been determined, but landslides and erosion are still considered moderate threats to water quality.

6.3.8 FIRES

The Valley Grassland vegetation in the San Luis Reservoir watershed is prone to natural fires. The area's semi-arid climate and windy conditions increase fire hazards in the area, especially along Highway 152, where fire incidents occur each year. Each fire burns from 10 to 150 acres (Gerstenberg pers. comm. 2001). Burned areas also become more susceptible to wind and soil erosion. The effect of this runoff on the reservoir's water quality has not been determined. However, runoff from the burned areas has the potential to increase nutrients, turbidity, and sediment loads in the reservoir.

6.4 WATER QUALITY SUMMARY

6.4.1 WATERSHED

In this and the other reservoir water quality sections, comparisons are made between contaminant concentrations in SWP source water and maximum contaminant levels (MCLs) for finished drinking water. MCLs are usually applied to finished water, but they are useful as a conservative indicator of source water contaminants that concern utilities and will require removal during the treatment process to meet finished water standards. If source water concentrations are below MCLs, then these contaminants are not as likely to be of concern to finished water supplies.

The comparisons also serve to focus on 1 or more PCSs associated with the contaminant of concern and allow the development of appropriate recommendations for actions. Although all data examined were below MCLs, land use and source water information suggested the possibility of several water quality concerns:

- High turbidity and total dissolved solids (TDS) levels in the reservoir,
- Algal blooms and taste and odor problems,
- High total organic carbon (TOC) and bromide concentration from the source water,
- MTBE from recreational watercraft in the reservoir, and
- Pathogen contamination through recreation and livestock grazing.

DWR's Division of Operations and Maintenance (O&M) routinely monitors water quality in the reservoir at the Pacheco Intake (Station SL005). Table 6-2 summarizes that water quality data for the period 1996 to 1999. Many organic compounds such as pesticides and petroleum byproducts were sampled but were not found above their reporting limits (Janik pers. comm. 2001).

Each statistic presented in Table 6-2 was calculated from only those analyses with data above the method reporting limit. Only constituents with 2 or more positive detects were presented. The number of positive detects and the total number of measurements were also presented in the table.

Table 6-2 San Luis Reservoir Water Quality Summary, Jan 1996 to Dec 1999[a]

Parameter (mg/L)	Mean[b]	Median[b]	Low[b]	High[b]	Percentile 10 to 90%[b]	Reporting Limit	# of Detects/ Samples
Minerals							
Calcium	19.9	19.8	18.0	26.0	19.0-22.0	1.0	48/48
Chloride	65	64	48	78	56-76	1	48/48
Total Dissolved Solids	248	245	194	295	224-277	1	48/48
Hardness (as $CaCO_3$)	100	99	90	123	92-110	1	48/48
Alkalinity (as $CaCO_3$)	78	78	71	89	73-83	1	48/48
Conductivity (umhos/cm)	448	446	363	501	403-488	1	48/48
Magnesium	12.1	12.0	11.0	14.0	11.0-14.0	1.0	48/48
Sulfate	36	35	27	45	31-42	1	48/48
Turbidity (NTU)	3	2	1	12	1-5	1	29/38
Minor Elements							
Aluminum	0.013	0.013	0.011	0.014	-	0.01	2/52
Arsenic	0.002	0.002	0.002	0.004	0.002-0.003	0.001	48/53
Boron	0.2	0.2	0.1	0.2	0.1-0.2	0.1	48/48
Chromium	0.006	0.006	0.005	0.007	0.005-0.007	0.005	5/53
Copper	0.004	0.002	0.002	0.014	0.002-0.009	0.001	30/53
Iron	0.011	0.009	0.006	0.021	0.006-0.106	0.005	5/52
Manganese	0.048	0.012	0.005	0.312	0.006-0.106	0.005	8/47
Selenium	0.001	-	0.001	0.001	-	0.001	2/47
Zinc	0.015	0.012	0.006	0.042	0.006-0.028	0.005	6/52
Nutrients							
Total Nitrogen[c]	1.0	1.1	0.7	1.4	0.8-1.0	0.1	27/27
Nitrate (as N)	0.6	0.6	0.1	0.9	0.3-0.8	0.1	45/47
Ammonia (dissolved)	0.03	0.02	0.01	0.10	0.01-0.06	0.01	22/47
Total Phosphorus	0.11	0.11	0.05	0.18	0.09-0.14	0.01	45/46
Orthophosphate	0.08	0.08	0.02	0.13	0.06-0.11	0.01	45/46
Miscellaneous							
Bromide	0.20	0.20	0.18	0.22	0.18-0.22	0.01	12/12
Total Organic Carbon[d]	2.7	2.7	2.0	4.1	2.2-3.1	0.1	92/92
pH	7.7	7.7	7.2	8.6	7.3-8.2	0.1	22/22

[a] Data were from DWR O&M Database, May 2000.
[b] Nondetects were not used for computation of these statistics.
[c] Total nitrogen was the sum of Kjeldahl nitrogen and nitrate.
[d] TOC data provided by Jeffrey Janik, DWR O&M, Feb 2001.

6.4.1.1 Minor Elements

Minor elements detected at low concentrations in 2 or more samples included aluminum, arsenic, boron, chromium, copper, iron, manganese, selenium, and zinc. In general, these elements are not considered a water quality concern in the reservoir. Minor elements with positive detection included aluminum, arsenic, boron, chromium, copper, iron, manganese, selenium, and zinc. Results for the minor elements in Table 6-2 represent the dissolved fraction. However, MCLs are based on total concentrations; therefore, strict comparisons between found concentrations and drinking water MCLs were not made.

Copper, iron, manganese, and zinc affect aesthetic quality of drinking water. During 1996 to 1999, they were detected at concentrations below their respective MCLs except for manganese (Table 6-2). The MCL for manganese is 0.05 mg/L. Among the 47 monthly samples, 8 samples had manganese above its reporting limit, and concentrations ranged from 0.005 to 0.312 mg/L. The sample that exceeded the MCL of manganese was in August of 1997 with a concentration of 0.312 mg/L. Manganese dropped below its reporting limit of 0.005 mg/L in September of 1997. This single incidence of high manganese was not likely to impact taste and order of water in the reservoir.

Two nonmetallic minor elements, arsenic and selenium, were detected in low concentrations during 1996 to1999. Arsenic was present in 90% of the samples collected at concentrations ranging from 0.002 to 0.004 mg/L (Table 6-2). These concentrations are much lower than 0.01 mg/L, California Department of Health Services (DHS) recently proposed MCL for arsenic. Selenium was detected at 0.001 mg/L in 2 of the 47 monthly samples during the survey period. The DHS MCL for selenium is 0.05 mg/L. Therefore, arsenic and selenium were not considered a threat to water quality in the reservoir.

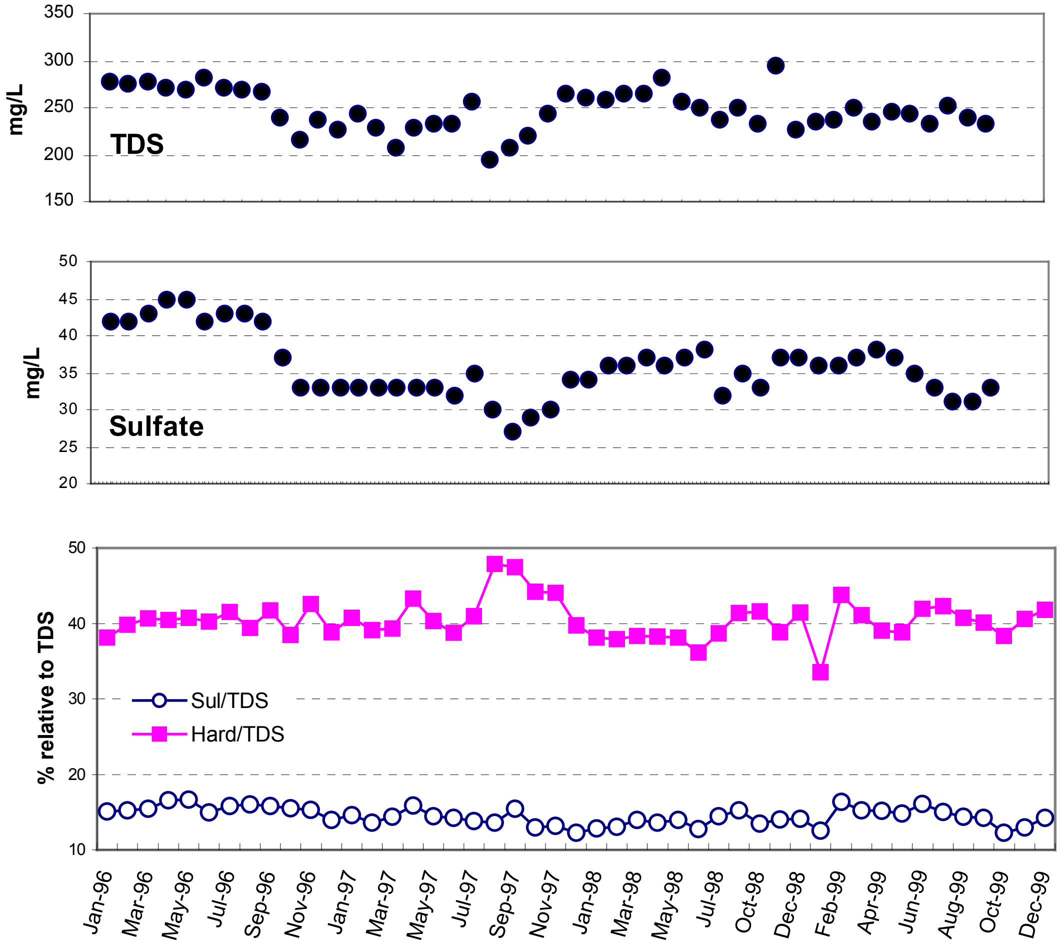
6.4.1.2 Total Dissolved Solids

TDS concentrations ranged from 194 to 295 mg/L and averaged 248 mg/L, significantly lower than the established drinking water MCL of 500 to 1,000 mg/L. TDS did not change significantly within a year nor from year to year (Figure 6-4). Sulfates and carbonates constituted a significant portion of the TDS. Sulfates ranged from 27 to 45 mg/L and averaged 36 mg/L. Concentrations of chlorides were from 48 to 78 mg/L and averaged 65 mg/L. Both the sulfates and chlorides were much lower than their MCL of 250 to 500 mg/L.

Conductivity was not high in the reservoir, and seasonal variations were small. From 1996 to 1999, conductivity ranged from 363 to 501 µmhos/cm and averaged 448 µmhos/cm. The MCL for conductivity is 900 to 1600 µmhos/cm.

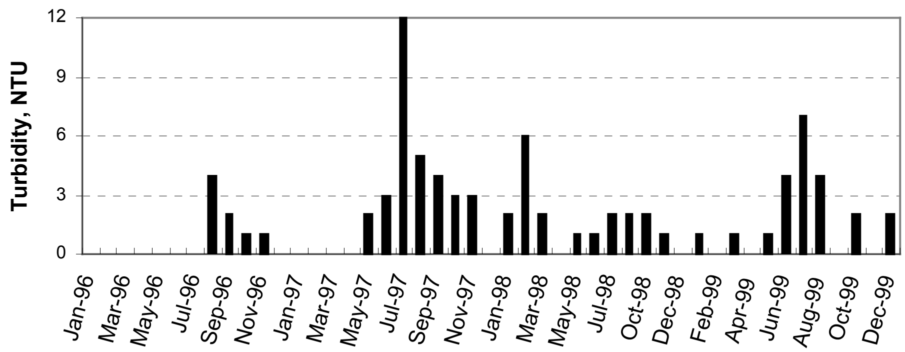
From 1996 to 1999, pH ranged from 7.2 to 8.6 with an average of 7.7. Most pH values were from 7.3 to 8.2, which fell within the drinking water MCL of 6.5 to 8.5. The pH measured at 8.6 in both July and August of 1998. It is unknown what caused the high pH during the 2-month period. As discussed in Chapter 5, this increase in pH and the decrease in nutrients (nitrogen in particular) may have resulted from algal blooms.

Figure 6-4 Total Dissolved Solids and Sulfates in San Luis Reservoir



Source: DWR O&M Database, May 2000

Figure 6-5 Turbidity in the San Luis Reservoir



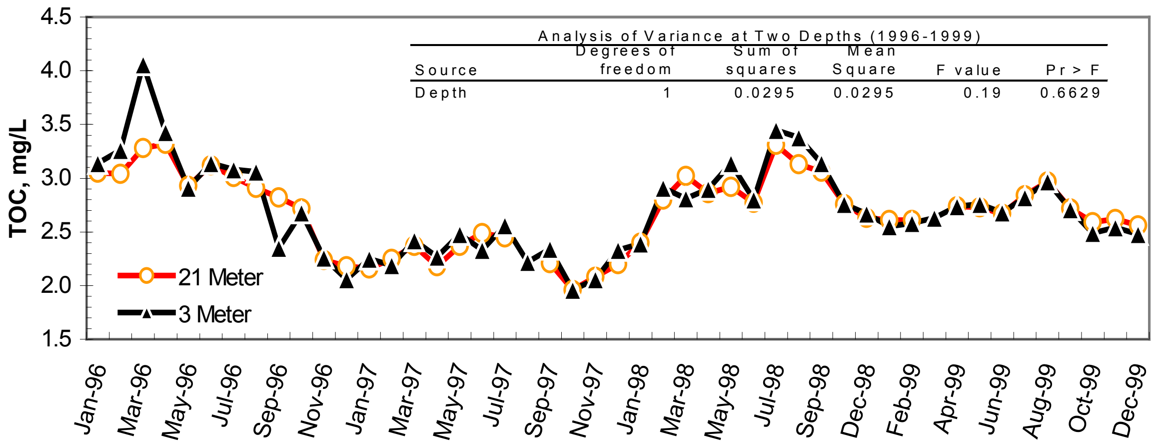
Source: DWR O&M Division Database, May 2000

6.4.1.3 Turbidity

Monthly turbidity data and seasonal variations during 1996 to1999 are summarized in Table 6-2 and Figure 6-5. The turbidity of 25% of the samples was below the reporting limit of 1 NTU. Turbidity for positive samples ranged from 1 to 12 NTUs and averaged 3 NTUs. Although the average was below the MCL of 5 NTUs for finished drinking water, 3 monthly samples were greater than 5 NTUs. The generally low turbidity in the reservoir is associated with the low natural inflows from its natural watershed. Turbidity spikes can occur during heavy rain and perhaps when recreational use of the reservoir is heavy. Turbidity in the reservoir may also come from extensive recreational activities in the watershed and source water from both the California Aqueduct and the DMC. Wave-washes from both wind and boat activities could contribute to turbidity, but supporting data were not available.

Data in Figure 6-5 appear to show that turbidity was highest in summer months, but insufficient data make it difficult to determine if recreational activities contributed to this increase in turbidity.

Figure 6-6 Monthly Total Organic Carbon Measured at 2 Depths



Source: SCVWD Feb 2001

6.4.1.4 Total Organic Carbon (DBP Precursors) and Alkalinity

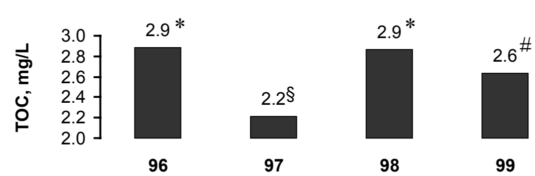
SCVWD monitored TOC monthly (SCVWD 2001). Samples were collected at the Pacheco Intake in the San Luis Reservoir from 2 different depths—3 meters and 21 meters—during each sampling day. Carbon concentrations changed little with depth except in March 1996 (Figure 6-6). An analysis of variance showed no significant difference between carbon concentrations measured at the 2 depths at the same site during the same sampling day TOC ranged from 2.0 to 4.1 mg/L with an average of 2.7 mg/L (Table 6-2). These TOC levels are considered high for source water but were lower than TOC measured at the Banks Pumping Plant (see Chapter 5)

Alkalinity of water in the reservoir ranged from 71 to 89 mg/L and averaged 78 mg/L (Table 6-2). According to the proposed Stage 1 Disinfectants and Disinfection Byproducts Rule (D/DBP Rule) and Interim Enhanced Surface Water Treatment Rule (IESWTR), 25% to 35% TOC removal is required for water in the reservoir.

There was no apparent trend in carbon levels within each year except in 1996 when carbon levels appeared to be higher January to March and started to decline the following months (Figure 6-6). There were significant differences in carbon levels among different years. The average TOC in both 1996 and 1998 was 2.9 mg/L, which was significantly higher than 1997 (Figure 6-7).

High TOC value in 1996 was possibly due to heavy rainfall in the watershed as well as high TOC in the California Aqueduct and the DMC. Rainfall was heavy in 1995 and heavier in 1996 in the San Luis Reservoir watershed. High TOC in 1998 was likely due to DMC water being the only source water from 14 January to 27 February 1998 because of a Banks Pumping Plant shutdown (see Chapter 8). TOC in DMC water was higher than normal from January to March 1998, probably attributable to the El Niño effect that caused heavy rainfall in California, especially in the Central Valley. Heavy runoff often followed heavy rainfall, resulting in increased TOC levels in the DMC.

Figure 6-7 Average Annual Total Organic Carbon Concentrations



Source: SCVWD Feb 2001
Note: Means followed by the same symbol are not significantly different at the 5% significance level by Duncan's Multiple Range Test.

Bromide, measured monthly in 1999, ranged from 0.18 to 0.22 mg/L with a mean of 0.20 mg/L (Table 6-2). These levels appeared to be higher than those in Southern California reservoirs (see Chapter 7) and exceeded a proposed drinking water protection standard of 0.05 mg/L. High bromide comes from source water from both the California Aqueduct and the DMC, which are affected by tidal inflows and seawater intrusion. Bromide in the DMC ranged from 0.04 to 0.42 mg/L from 1996 to 1999 (see Chapter 8).

6.4.1.5 MTBE

As discussed in Section 6.3, there are boating activities in the reservoir that could contribute MTBE. According to a 1997 study by the O&M, MTBE did not appear to be a serious water quality concern in the reservoir (Janik 1999). A total of 34 surface water samples were collected from May to October 1997. Sixteen of these samples were taken at 3 depths—0.5 meters, 8 meters, and 20 meters—at the trash racks where water from O'Neill Forebay enters the reservoir at the Gianelli Pumping-Generating Plant. Six samples each were collected at 0.5 meters at the Pacheco Intake, Dinosaur Point boat ramp, and Basalt Area boat ramp. Of the 34 samples analyzed, only 1 sample at the Dinosaur Point boat ramp measured at 0.002 mg/L.

6.4.1.6 Pathogens

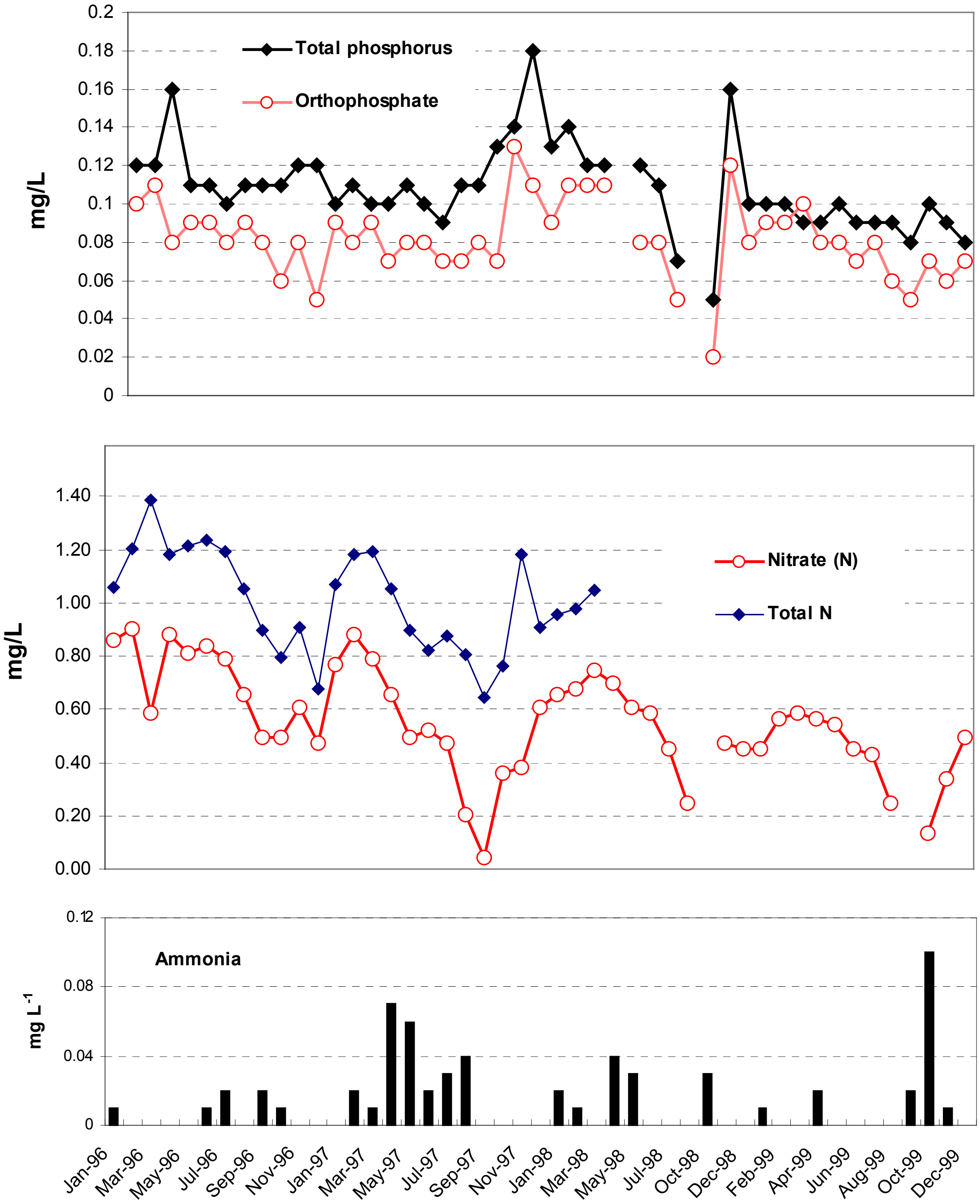
Pathogens are discussed in Section 6.4.1, Water Supply System, and in Chapter 12.

6.4.1.7 Nutrients

Among various nutrients, only nitrate and nitrite are considered mandatory health-related constituents with established drinking water standards. In this section nitrogen and phosphorus will be considered together. Nitrogen and phosphorus act collectively to stimulate growth of algae and, subsequently, may affect water quality by forming taste and odor-producing compounds.

Table 6-2 summarizes nutrient data collected in the reservoir from 1996 to 1999. Figure 6-8 presents seasonal variations of nitrogen and phosphorus. Total nitrogen ranged from 0.7 to 1.4 mg/L with an average concentration of 1.0 mg/L. More than 60% of the total nitrogen was in the nitrate form (Figure 6-8), which averaged 0.6 mg/L and was below the MCL of 10 mg/L. Nitrite was also monitored, but concentration was negligible and was not presented in Table 6-2. Concentrations of both total nitrogen and nitrate appeared to follow the same cyclic pattern in any given year. Nitrogen was generally higher in the earlier months of the year and declined in later months, although some variations occurred. Ammonia was frequently detected in the reservoir with concentrations ranging from 0.01 to 0.10 mg/L (Table 6-2).

Figure 6-8 Nutrient Concentrations in San Luis Reservoir



Source: DWR O&M Database May 2000

Total phosphorus was detected in 45 out of 46 samples and ranged from 0.05 to 0.18 mg/L with an average of 0.11 mg/L. The phosphorus was mostly as orthophosphate (Figure 6-8). Neither total phosphorus nor orthophosphate showed a seasonal variation as nitrogen did. Both forms of phosphorus remained relatively stable with some fluctuations, especially in July and August of 1998.

The changes of nitrogen and phosphorus appeared to coincide with the growth of algae in the reservoir. During July and August of 1998, levels of both nitrogen and phosphorus were significantly lower, and pH was 8.6 for the same 2-month period (see Section 6.4.1.2). It appeared that the decrease in nutrients during summer months was related to algal blooms in the reservoir.

According to a recent EPA nutrient criteria guidance for lakes and reservoirs (EPA 2000), when phosphorus and nitrogen in the reservoir are high, algal growth is likely if other enrichment conditions are met. Algal blooms are triggered by a complex interplay of nutrients, species interactions, and physical conditions such as temperature and light levels in the reservoir. Although nutrients were not limiting for algal blooms in the reservoir, other factors did not appear to favor algal blooms, as mentioned in Section 6.3.4. However, algal growth and taste and odor were not a problem with water from the San Luis Reservoir (Janik pers. comm. 2001).

6.4.2 WATER SUPPLY SYSTEM

As discussed earlier, the San Luis Reservoir is a major offstream storage facility. The SCVWD withdraws water from the reservoir for treatment and distribution through the district's Santa Teresa, Rinconada, and Penitencia water treatment plants. The SCVWD's annual entitlement for federal water, that is, water from San Luis Reservoir, is 152,000 af (Matthews pers comm. 2001). The Santa Teresa and the Rinconada water treatment plants use about two-thirds and one-third of this annual entitlement of federal water, respectively. The Penitencia Water Treatment Plant is not a major treatment plant for water from the reservoir (Matthews pers comm.). At the Santa Teresa Water Treatment Plant (WTP), water quality at the intake is routinely monitored.

Table 6-3 details sampling activities during 1996 to1999. The sampling dates included in Table 6-3 are the dates when the source water for the plant was 100% water from the San Luis Reservoir. Table 6-4 summarizes water quality data. Statistics in Table 6-4 were calculated from only those analyses with data above the method reporting limit as described in Section 6.4.1. Only constituents with 2 or more positive detection are presented.

Table 6-3 Sampling Activities at the Santa Teresa Water Treatment Intake[a]

Sampling Dates	Sampling Frequency	Constituents Analyzed
1 Jan 1996 to 30 Dec 1999	Daily	Alkalinity, conductivity, hardness, pH, and turbidity
12 Nov 1996 to 30 Dec 1999	Daily	Chloride
Jan 1996 to Aug 1999	Monthly	Calcium,TDS, TOC, and UVA
Jan 1996 to Dec 1999	Monthly	Bromide, sulfate, nitrate, and orthophosphate
Jan 1996 to Jul 1999	Monthly	Aluminum, arsenic, barium, chromium, copper, iron, manganese, nickel, and zinc

[a] Source water at the intake was 100% San Luis Reservoir water.

Table 6-4 Water Quality Summary at Santa Teresa Water Treatment Plant, Jan 1996 to Dec 1999[a]

Parameter (mg/L)	Mean	Median	Low	High	Percentile 10 to 90%	Detection Limit	# of Detects/ Samples
Minerals							
Calcium	22.0	22.0	19.0	28.0	20.1-23.0	1.0	22/22
Chloride	63	60	46	144	56-78	1	389/389
Total Dissolved Solids	239	241	140	315	207-276	1	20/20
Hardness (as $CaCO_3$)	96	96	55	134	87-106	1	564/564
Alkalinity (as $CaCO_3$)	71	72	57	108	64-74	1	560/560
Conductivity (µmhos/cm)	394	393	239	616	343-451	1	564/564
Sulfate	38	38	27	46	32-44	1	33/33
Turbidity (NTU)	2	2	1	19	1-4	1	562/564
Minor Elements							
Aluminum	0.32	0.28	0.04	0.79	0.09-0.55	0.01	17/17
Arsenic	0.003	0.002	0.002	0.005	0.002-0.004	0.002	9/17
Barium	0.04	0.04	0.04	0.05	0.04-0.05	0.05	16/17
Chromium	0.0007	0.0006	0.0005	0.0010	0.0005-0.0010	0.0005	8/17
Copper	0.005	0.004	0.002	0.013	0.003-0.007	0.001	16/18
Iron	0.195	0.158	0.093	0.350	0.106-0.318	0.005	17/17
Manganese	0.031	0.016	0.006	0.120	0.010-0.097	0.005	17/17
Nickel	0.003	0.000	0.002	0.004	0.002-0.004	0.002	6/17
Zinc	0.034	0.038	0.005	0.054	0.011-0.052	0.005	5/17
Nutrients							
Nitrate (as N)	2.6	2.4	0.2	5.1	0.7-4.5	0.1	32/32
Orthophosphate	0.25	0.24	0.09	0.39	0.18-0.36	0.01	33/33
Misc.							
Bromide	0.19	0.21	0.04	0.30	0.10-0.25	0.01	30/32
Total Organic Carbon	2.7	2.7	1.9	3.5	2.1-3.4	0.1	24/24
pH	7.7	7.7	7.1	8.9	7.4-8.1	0.1	566/566
UVA (cm^{-1})	0.096	0.090	0.069	0.143	0.071-0.129	0.001	20/20

[a] Data provided by Matthews pers. comm. Raw water was 100% from the San Luis Reservoir. Nondetects were not used for computation of statistics.

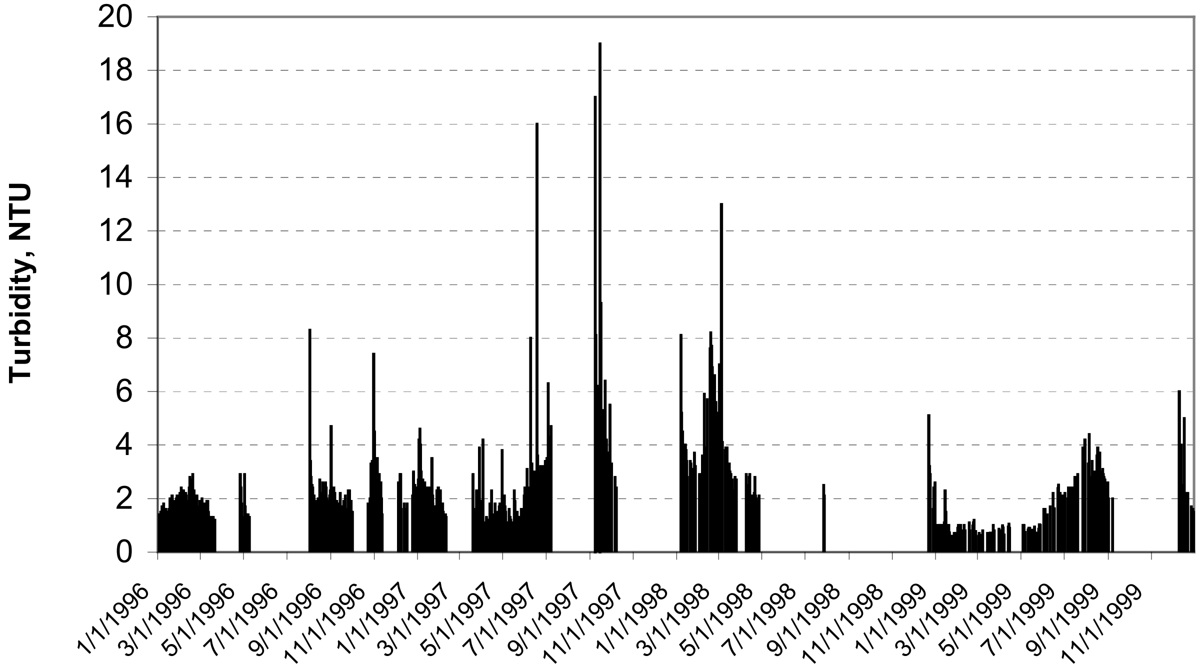
6.4.2.1 Minor elements

Average concentrations of all minor elements were below their respective MCLs (Table 6-4). This is consistent with findings presented in Section 6.4.1.

6.4.2.2 Turbidity

Turbidity of water at the Santa Teresa WTP intake ranged from 1 to 19 NTUs and averaged 2 NTUs (Table 6-4). Figure 6-9 shows the seasonal pattern of turbidity in the reservoir. The turbidity was occasionally high, particularly during winter months from 1996 to 1998 (Figure 6-9), and appeared to coincide with heavy rainfall. High turbidity may also occur in late summer and fall as shown in Figure 6-9 in 1997. Algal blooms caused this high turbidity. From late summer to fall each year, water levels in the reservoir are usually very low. Because water in the reservoir is high in nutrients (see Section 6.4.1.7 and Table 6-4), the nutrient-rich water causes algal blooms. The algae die and decay in the fall, which increases turbidity and produces offensive odors (Matthews pers comm.). When this happens, the Santa Teresa WTP stops taking water from the reservoir. Instead, the SCVWD takes its water mostly from the South Bay Aqueduct (Matthews pers. comm.)

Figure 6-9 Turbidity in Raw Water at the Santa Teresa Water Treatment Plant[a]



[a] Source was 100% from San Luis Reservoir.

6.4.2.3 Total Organic Carbon (DBP Precursors) and Alkalinity

TOC ranged from 1.9 to 3.5 mg/L and averaged 2.7 mg/L (Table 6-4). These TOC concentrations are considered high and were similar to those in the San Luis Reservoir (Table 6-2). Alkalinity ranged from 57 to 108 mg/L and averaged 71 mg/L, which were also similar to those in the San Luis Reservoir. According to the proposed Stage 1 D/DBP Rule and IESWTR, a 25% to 35% TOC removal is required for water in the reservoir.

Bromide was detected in 30 of the 32 monthly samples with an average of 0.19 mg/L (Table 6-4), which exceeded the proposed drinking water protection standard of 0.05 mg/L. These levels are approximately the same as those found in San Luis Reservoir (Section 6.4.1). As discussed earlier, high bromide comes from source water from both the California Aqueduct and the DMC, which are affected by tidal inflows and seawater intrusion.

Table 6-5 Pathogens in Source Water at Santa Teresa Water Treatment Plant, 1996 to 1999[a]

	Mean	Median	Low	High	Percentile Range (10-90%)	# detects/ total sampled
Total Coliform	15	8	2	500	2 - 23	120/160
Fecal Coliform	9	4	2	50	2 - 17	74/161
E. Coli	8	4	2	50	2 - 17	72/161
Cryptosporidium	ND[b]	-	-	-	-	0/11
Giardia	ND[b]	-	-	-	-	0/11

[a] Data were provided by David Matthews, Santa Clara Valley Water District, 23 Jul 2001. Raw water was 100% from the San Luis Reservoir. Nondetects were not used for computation of statistics.
[b] Samples tested by both the ICR Method and Method 1623; results were below their respective detection limits.

6.4.2.4 Pathogens

This section addresses pathogen data collected from the Santa Teresa WTP only when the San Luis Reservoir was the sole source. See Chapter 12 for a more comprehensive discussion on pathogens in the reservoir. The Santa Teresa WTP routinely monitors microbiological constituents in its raw water. During the survey period from 1996 to 1999, microbiological data were available from January 1996 to December 1999. Table 6-5 summarizes monitoring data for raw water that is 100% from the reservoir. The data presented in Table 6-5 were calculated in the same manner as described in Section 6.4.1.

The pathogens *Cryptosporidium* and *Giardia* were monitored, but only 11 measurements were available for each of the 2 organisms during the survey period. Two different methods, the ICR IFA method and EPA Method 1623, with different detection limits were used to test each organism. Results were both negative for both organisms (Table 6-5).

Data on coliform bacteria in raw water from the reservoir at the Santa Teresa WTP are presented in Table 6-5. Among the 160 to 161 samples tested, 120, 74, and 72 tested positive for total coliform, fecal coliform, and *E. coli*, respectively. These bacterial levels were all below the state regulatory numerical values for freshwater beaches (DHS 2000).

6.5 SIGNIFICANCE OF POTENTIAL CONTAMINANT SOURCES

Water in the San Luis Reservoir is pumped from both the California Aqueduct and the DMC during fall and winter months. Significant contaminant sources and water quality problems at the reservoir are associated with watershed activities and the source water from the aqueduct and the DMC. Water quality constituents of concern in the reservoir include turbidity, TOC, and bromides. Turbidity can be a serious problem during fall and winter months.

PCSs in the watershed include recreation, animal populations, fires, and highway hazardous chemical spills. Water quality concerns associated with recreation at the watershed include pathogens and turbidity caused by erosion in camping grounds, wildlife areas, and wave-washes of reservoir shorelines. Although not quantified, body contact recreation may also be a major source of pathogens. The contribution from animal populations is unknown, but animal grazing and wildlife also may contribute nutrients, pathogens, and turbidity to the reservoir. Fires in the watershed of the reservoir contribute turbidity and nutrients indirectly. No spills occurred during the survey period, but hazardous chemical spills along Highway 152 may present a potential threat to water quality because of the extent and proximity of the highway to the reservoir, as well as the types of transportation activities that occur along the highway.

The California Aqueduct and the DMC are the major sources of TOC, bromide, and, sometimes, turbidity in the reservoir. Levels of TOC in the reservoir and in raw water at the Santa Teresa WTP often exceeded the target drinking water protection standard of 3 mg/L, and occasionally were above 4 mg/L. Bromide levels also exceeded the target drinking water protection standard of 0.05 mg/L. The high levels of TOC and bromide in water of the California Aqueduct and the DMC present challenges to meeting the regulatory limits set by the Stage 1 D/DBP Rule and IESWTR.

6.6 WATERSHED MANAGEMENT PRACTICES

DWR and the BLM own most of the land in the San Luis watershed, and several agencies manage the watershed area. DWR constructed the reservoir and is primarily responsible for its operation and maintenance. California State Parks manages the recreation activities within the watershed. The California Department of Boating and Waterways regulates recreational boating in the reservoir. The California Department of Fish and Game manages wildlife areas, hunting, and fishing in the watershed and in the reservoir. Most privately owned land is not close to the reservoir.

Recreation represents a challenge in watershed management in the future because recreational use of the reservoir is expected to rise with the lower admission fees. Recreational activities often can be significant sources of contamination. Although most of the reservoir shoreline is fenced, a considerable portion is not fenced. Animals may be in direct contact of the water in the reservoir. At the present time, contamination does not appear to be serious, but interagency coordination and strategies may be needed to address the challenges of increased recreational activities in the watershed.

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